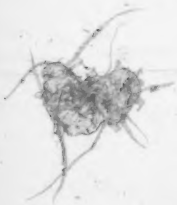
apuryamanam acala-pratistham
samudram apah pravisanti yadvat
tadvat kama yam pravisanti sarve
sa santim apnoti na kama-kami

Bhagavad-Gita: TEXT 30

A person who is not disturbed by the incessant flow of desires - that enter like rivers into the ocean which is ever being filled but is always still - can alone achieve peace, and not the man who strives to satisfy such desires.

Bhagavad-Gita



University of Alberta

INTERACTIVE MULTIMEDIA APPLICATION FOR TEACHING ADAVU IN BHARATA NATYAM (IMATAB).

by

SHYAMALA NAGENDRAN

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science.

Faculty of Physical Education and Recreation

Edmonton, Alberta

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Date 25th/Jan./95

Abstract

The concern of losing the integrity and purity of the movements of Bharata Natyam(BN), - an East Indian classical dance form, prompted this research. Teaching and archiving for the purpose of preserving Bharata Natyam in the Western hemisphere is the primary purpose of this project. One of the research challenges was to find a medium suitable for the proposed assignment.

The medium had be technically sophisticated in order to capture and disseminate the essence of Bharata Natyam in its original form. It had be accessible, providing immediate usefulness to the dance community. The most effective method for accomplishing this task was a computerized multimedia environment. Implementing the research goal resulted in the ***Interactive Multimedia Application for Teaching Adavu in Bharata Natyam.***

Acknowledgments

I would like to extend my sincere appreciation to my supervisors Dr. Marsha Padfield and Dr. Ken Fyfe for their support and encouragement throughout the course of my studies. Many thanks to Marsha, who has been practical-minded, steadfast and motivating. Likewise to Ken, who has given valuable support and advice for this research. To the rest of my committee members Dr. Romeo Chua and Dr. Andriy Nahachewsky who provided valuable insight for this thesis, a sincere thank you.

Thanks to Dr. Tom Calvert for his generosity in providing me with "Lifeforms" software and motivating me by having faith in my research, to Dr. Jane Watkinson and the Faculty of Physical Education for providing me with the required computer equipment, to Info-Drive for the use of audio, video clips, to my friends Sheila Gillen and Cathy Anne Paschnowski for their enormous support and encouragement, particularly Sheila for keeping me sane.

It is with great gratitude I extend a "soulful" thank you to my family. My brother Giri for his interest, opinions and advice, thanks *thambi*, and the rest of my entire family, my husband Jay and my sons Jayan and Jeevan, my mother Gowri, and my father Ratnasingham. Without them this Master's thesis would not have been possible. They have all been an unlimited source of love and support, and this Master of Science belongs to them as much as to me.

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Introduction

A personal desire to teach and preserve Bharata Natyam (East Indian Classical Dance) in its original form in the Western hemisphere has led to the merger of two diverse disciplines; the art form of Bharata Natyam and Computer Science. The result is **Interactive Multimedia Application for Teaching Adavu in Bharata Natyam (IMATAB).**

As it is an interdisciplinary study the Thesis has three phases to it. Phase one is titled *"Description of Bharata Natyam"* and is in text format. It provides a brief historical overview of Bharata Natyam, identifying dance notation systems (Laban and Benesh) used to describe and analyze dance predominantly in the West. Also reviewed were existing methods used to describe and analyze Bharata Natyam, identifying the need for a unique description system specific to Bharata Natyam to the purpose of teaching Bharata Natyam. This resulted in the Nagendran Description System that breaks the body into three units, and the body units were analyzed in relation to kinematic elements.

Phase two is the computer tool, *"Interactive Multimedia Application for Teaching Adavu in Bharata Natyam (IMATAB)"* in computer medium.

Phase three is titled *"The Developement of Interactive Multimedia Application for Teaching Adavu in Bharata Natyam (IMATAB)"* in text format. A brief overview of research dealing with technology and dance was presented.

Techniques employed to animate movement were reviewed making use of available technology. The Interactive Multimedia Application for Teaching *Adavu* in Bharata Natyam (IMATAB) was designed keeping the research goal of teaching and archiving Bharata Natyam in focus. IMATAB fulfills the dual purpose of being a teaching tool, as well as an archival data base for posterity. The research has provided an algorithm to create a tool for the purpose of teaching Bharata Natyam, that has immediate usefulness and accessibility for the dance community. The usage of IMATAB was discussed with some thoughts on future research in an inter disciplinary environment.

Phase I

Description of Bharata Natyam

Chapter 1

Introduction

Education in Bharata Natyam (BN) is a complex task, it involves learning an artform in its full contextual spirit with the cultural, philosophical and religious aspects that are characteristic of its society, as well as mastering diverse and complex movements. Therefore, endeavors to design a descriptive system for BN should keep these concepts in mind in order for the system to be complete. Western society has created and adopted systems of analysis for dance that are well established such as the Laban and Benesh systems(J. Mc-Guinness-Scott 1983, A. Hutchinson 1954, 1984). Literature review reveals that analysis of BN has been minimal, the existing attempts are not comprehensive and furthermore confusing at times (F. Bowers 1953, P.K. Ravindranath 1980, K. Vatsyayan 1974).

The following work is an attempt to develop a better understanding and description of BN. This method explores the possibilities of studying the *adavus* (steps) via kinematic principles of time, space, energy, where the body is grouped into three units.

1.1 Historical Background of Bharata Natyam

Bharata Natyam is an East Indian classical dance form originating in India. In order to fully analyze and understand the dance movements of BN it is imperative to understand the inception of this art form. Unlike other dance forms, BN has its origin in the Hindu religion and is inseparable from the religion, hence it cannot be understood in isolation. Based on its technical movements alone, this art form will withstand rigorous scrutiny as a performance art. But as its depth is derived from religion, it has to be comprehended as a complex synthesis of religion, culture, music and literature to be fully understood and appreciated.

According to literature (P. Banerjee 1982, V.P. Dhananjayan 1984, M. Ghosh 1975, S. Kothari 1979, K. Vatsyayan 1974 & 1988) the monumental work of Sage Barata in the *Natyasastra*, created in the 2nd century B.C., endowed the development of all arts in India. The next written source on dance was the *Abhinaya Darpana* by Nandikesvera written approximately 1000 A.D., and is a treatise on dance. From the Sanskrit literature of the classical period, it becomes clear that the poet and dramatist were well versed in the techniques of dance. The Hindu scriptures the Upanishads, propound, "Devo bhutva devam yajet"- become a god to worship god. India has embodied this eternal principal in its culture, dancing was considered the religious ceremony most pleasing to the Gods and dedication of all activity to the divine was the highest form of worship. According to Hindu mythology, dance was derived from Lord Shiva who was said to have performed the "Cosmic Dance" to create the universe.

Bharata Natyam treats the human form as the vehicle of artistic expression devoted to Gods. It is not an accident that the dancing *Nataraja* (another form of Lord Shiva) represents the spiritual and artistic faith of human kind. This image is the supreme symbol of all aspects of life where dance itself represents the syntheses of all aspects of creativity. Artistic creation/choreographing is regarded as the supreme means of realizing the universal Being. Art was considered a discipline, a yoga. The combination of movements and emotions creating a dance sequence is considered to achieve a state of complete harmony, leading to the recognition of one's true self. The spiritual virtuosity of Bharata Natyam has dulled over the centuries, however, it is not eliminated. Without the spiritual virtuosity as well as the movement virtuosity there can not exist Bharata Natyam, as it is the dance of the creator.

The aesthetic enjoyment of classical Indian dance vastly depends on the audiences. As the dance itself is contextual and derives from tradition, in order to fully understand and identify with the dancer, the audience requires cultural awareness. Literature review reveals that Bharata Natyam originally was danced by virgins in the temples as worship to the gods. As the art form moved from the temples to the stages it began to digress in virtue, the decline of the art reflected the state of society and its' governing bodies (P. Banerjee 1982, V. P. Dhananjayan 1984, S. Kothari 1979, K. Vatsyayan 1974 & 1988). However, under the regime of Pandiya Maharaja the purity and virtuosity of the dance was restored, becoming the mainstay of cultural activity which gained respect and admiration (F. Bowers 1953 , p 15). The Hindu mind views the creative process as a creation of a vision, a divine truth.

Therefore it is not surprising that the art of creating and performing dance was regarded as a means of experiencing the state of bliss. This is not to be confused with frenzied or hypnotic dances with hallucinogenic movements that are found elsewhere in the arts in India.

Indian architecture, sculpture, painting, music and dancing evolved their own rules conditioned by religion, and as such social changes had minimal influence over the arts. Bharata Natyam relied on the Hindu-philosophic mind and most often depended on the sculptures of the temples to express stances and characters. Indian sculpture, like Indian architecture springs from a deep spiritual realization of the Divine and the Infinite.

Present day Bharata Natyam has predominantly been rooted and grown from Tamil-Nadu, (south India), two important Tamil works from the literature *Silappadikaram* and *Maimekhalia* (500 B.C - 500 A.D.) gave prominence to the art form. Endorsed by the rulers Pallavas and Cholas (4 A.D. - 12 A.D.), Bharata Natyam flourished, elevated in its status. The Kings' testimony of their devotion to religion and the arts can be witnessed in the architecture, sculpture and paintings of the magnificent temples in the south. The Chola kings maintained hundreds of dancers in the temples, they took pride in nurturing and maintaining the tradition and culture. As Kothari (1979) claims, this deep rooted devotion to maintain the culture can be still witnessed in the arts in the Indian society.

In the present century, Bharata Natyam became the national art form of India, its progression and evolution can be witnessed in the many dance schools spread out all through India. Some Universities have housed dance within their educational

system either by employing dance masters (guru) within their system and/or incorporating dance within their academic curriculum. At the international dance conference held in Hong Kong in 1990, Vatsyayan stated that even though dance has been recognized as a discipline in its own right it should be classed not only as a study of a set of movements, but also as an academic study which supports the research into movement, analysis of movements, description and categorization of movements, classification of movements and interpretation of movements. Furthermore, Vatsyayan claims (1995, p 486-490) that the texts dated back from the fifth century B.C. written on dance need re-examination of its content and identify the challenges that face current day researchers in the field of dance, emphasizing the need for analytical tools.

1.2 Basic Characteristics of Bharata Natyam (BN)

Traditionally BN is performed to vocal and instrumental orchestra; it is predominantly performed as a solo where the dancer depicts a spiritual story. The art form requires rigorous training for many years, it demands the commitment of the soul and body to unify in performance. It is predominantly performed by females, beginning their study of the artform at five years of age.

Literature review reveals that Bharata Natyam can be categorized into two major components; *Bharata* and *Natyam*. *Bharata* can be articulated as *Bhava, Raga and Tala*. *Bava* is the mood of expression, *Raga* translated is melody and *Tala* means rhythm. *Natyam* has three aspects to it as well; *Nritta, Nritya* and *Natya*.

Nritya is gesticulator exposition in dance involving eye and neck movements with no verbal connotations. *Nritta* is pure dance steps with artistic poses. *Natya* is the total representation of *Bava, Tala, Raga, Nritta*, and *Nritya* combined in meaningful composition of movements.

Bharata Natyam is spiritual; sexual connotations are not even remotely expressed. Any form of love is always expressed in a spiritual format as devotion to one of the gods. Often expressing a mythological story, emotions are expressed facially, with gestures, poses and stances drawn from temple sculptures. These poses stem from the base of the spine, with the center of gravity between the pelvic bones, the movements of the upper body are anchored at the hip and there are very few jumps or leaps.

The characters that are presented in BN are not only of the gods, goddesses and demons of Hindu mythology, but also of heroes *(nayaka)* and heroines (*nayaki*). BN is built on literature which has been set to music. The music evokes the state before the performer appears, thus preparing the audience to receive the visual art. The movements deliberately differ from life-like gestures, they emphasize stylization of presentation through emotion. Costumes and make-up form the resemblance to drama, however, it is for most part void of stage scenery.

Most all movements can be divided along the vertical axis that will run from the top of the head through the pelvis. The center of gravity can be identified as the point between the pelvic bones. The weight of the body acts through this center. According to the treatises, *Natyasastra,* there are two groupings for body movements in Bharata Natyam; (Vatsyayan 1974), they are the major and minor limb movements.

The major limbs (*ungas*) are comprised of head, hands, torso, hips and feet. The minor limbs (*upangas*) are the eyes, eyebrows, nose, lips, chin, and mouth. He does not classify the neck, arms, abdomen, shanks and knees in either category.

When the weight is equally divided and acting through the center of gravity a balanced position is attained. In *Abhinaya Darpana*, this position is called *samabhanga.* When there is one deflection that creates an imbalance position it is called *abhanga*, when there are three deflections the position is called *tribhanga*. The dancer begins with the *samapada* position, which is the first basic position, with the feet facing front, arms bent at the elbows with wrists placed at the waist. The body of the dancer is neither relaxed or unduly taut, facing forward, the eyes are focused straight ahead. This is followed by turning of the feet to the sides with knees bent to the sides. This is called the *aramadali* position; the pivotal stance in BN, the entire movement/steps of BN are built from this *aramadali* position.

Feet are the body parts that speak volumes in BN. Their contact with the ground is always conscious, never accidental or unplanned. Their deliberate contact evokes the senses to sounds that are textured and alter tempos. The multi purpose functionality cannot be emphasized enough. Feet convey movement, rhythm, sound, speed and balance. They have and maintain a special relationship with the *murthangam* instrument player, breathing life, energy, and spirit to a BN performance via movements, all the while maintaining the *kalam* (tempo) required.

There are three main variations of foot positions. The basic position is where they are flat on the ground with the whole foot touching the ground and weight is distributed evenly onto both feet. The second type of foot contact to the ground is

when the balls of the feet and toes touch the ground and the heel is raised. The third is when the heel touches the ground and the toes are raised. All feet movements are derived from a combination of these positions.

Derived from *Natyasastra* and *Abhinaya Darpana* (R. Kumar, M. Sarabhai, K. Vatsyayan), the combination of the arms, body and feet in motion is called *adavu*. The *adavus* form the basis of BN, and are what a student first studies. These adavus are categorized with sub-categories within each group. There is no universal categorization of BN steps, however some common categories and sub-categories have emerged over the centuries. These adavus with their varied combinations can be set in composition to any given time cycle. *Jethi* is the verbal sound syllable that indicate rythmic pattern. These vary in pattern and tempo, strung together in different time measures they are called *thrimanams*.

Symmetry is an important element in BN, all movements are executed on the right side first and repeated onto the left side. This motion isolation to one side produces a static quality to the opposite side of the movement. The movement is conceived in relation to the ground and the vertical plane.

Hand gestures called *hastas* are also a pivotal part of BN. They have dual purpose; hand gestures are used to convey meaning and expression, as well as being used for pure decorative stance where no meaning is conveyed. The Hastas are also used to guide the eye movements. Subramaniam (1980, p23) claims that " The fingers in BN speak an eloquent language of their own. They stretch, fold, raise, lower, close, open separate and join to create variegated hand patterns called *mudras* or *hastas*". He classifies them into 28 hastas, each held at different angles from the

body to express various thoughts. According to Kothari (1979, p71), the Hastas are classified into three categories in *Natyasastra*. They are *asamyuta* (single), *smayuta* (double) and *nirtta* (pure dance). Various other treatises have also classified these hand gestures, but once again there exists no unanimous agreement amongst these groupings. However, the popular classification is derived from *Abhinaya Darpana*. *Hastas* become essential to express the meaning of a song, either literally or in subtle gestures (Ghosh, 1975). An illustration of *hastas* is seen in Figure 1, depicting the sculptural image of Lord *Siva* as *Shivalinga*.

Figure 1

Once the student has mastered some of the BN movements they give recitals. A typical recital commences with the dancer moving to the rhythmic vocalization of a salutation to the gods and moves into depicting the rhythm via various forms of dance. Dancers are admired for their ability to relate to the audience through emotional expressiveness and skilled physical demonstrations. According to M.

Sarabhai (1965), the dance becomes so personal and intimate an expression that the one who sees often becomes one with the one who seeks; that is, with the performer. This she claims is the true power of BN. After a progressive learning period of 4 to 5 years, the culmination of learning results in the graduation of the student of this art form called **Arangetram**. It is a three hour solo performance an artist gives as the culmination of her/his learning, it is a public approbation after which one is licensed as a professional artist.

Chapter 2

Dance Description

An ideal system of dance description would be something that would universally apply to all dance forms, however, given the diversity of the nature of dance, no system can possibly accomplish this task. Therefore, one needs to arrive at the most suitable method of description for the chosen dance form. It may be appropriate to evaluate many systems adopting and rejecting portions of them until one devises a unique system of description that can be used to describe the chosen dance form.

2.1 Labanotation

The Laban and Benesh notation systems provide a strong base for dance analysis and description, and as such are discussed in this chapter for context. The Labanotation is a two dimensional graphic notation system used for the recording of human movement. It was published in 1928 by Rudolf Laban in the journal *Schrifttan* (A. Hutchinson, 1954). Labanotation is predominantly a tool for recording movements, subsequently it has been used to analysis movements. It provides three types of descriptions: motif, effort-shape and structural. The structural system or full notation is referred to as Labanotation (LN) in the US, or Kinetography Laban (KIN) in Europe. Labanotation is written on a vertical staff which is read from the bottom

up (see Figure 2). This staff represents the body. The center line of the staff represents the center line of the body, dividing right and left. Vertical columns on each side of the center line signify main parts of the body. By placing symbols in one of the vertical columns of the staff an action for one of the main parts of the body is represented. Movements of more specific parts of the body are written with specific signs for those parts, written as pre-signs before the action symbols for that particular part, placed in the column most relevant. The following figure illustrates the Laban staff.

Laban Staff

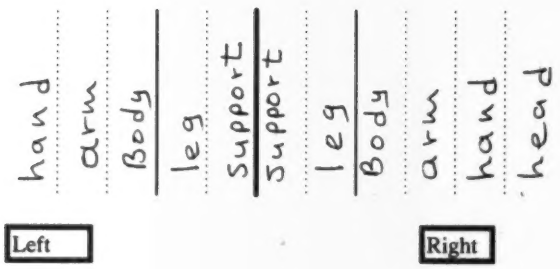
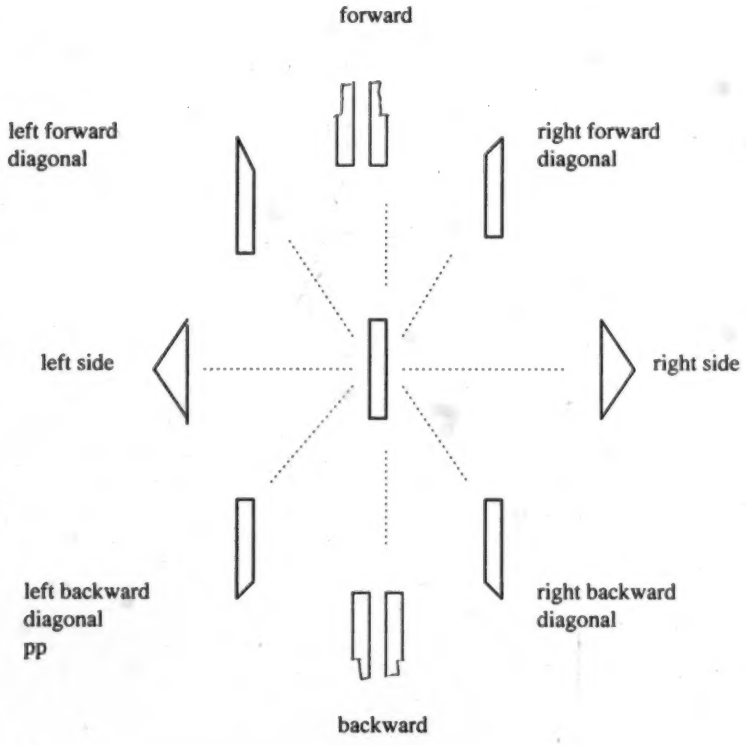


Figure 2

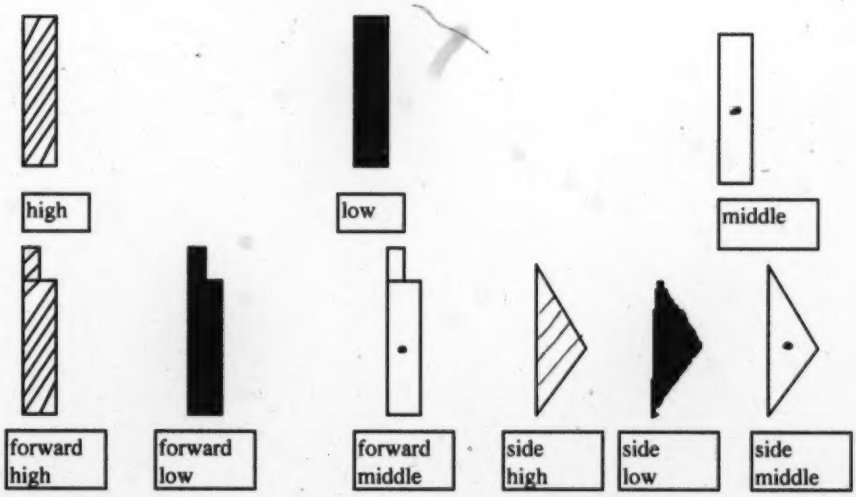
Direction symbols signify the direction in which the body parts travels. A direction symbol on the staff indicates which part of the body is moved in the particular direction. The direction symbols are shaded to indicate whether the movement is high, middle or low in levels. The direction symbols are shown in Figure 3.

THE EIGHT MAIN DIRECTIONS

Figure 3



INDICATION OF LEVEL



In addition to the main direction symbols, there is an assortment of other symbols to signify movements such as rotation/twists, extension/flexion, shift and facing and other parts of the body. All of these movements can be performed by individual parts of the body, or by the body as a whole.

The center line of the staff is also the time line and is read from the bottom up. The relative length of each movement symbol indicates its time value. The longer a symbol on the staff, the longer it takes to complete the given action. Slower movements are indicated by shorter symbols. The staff may be further divided into measures and beats, or not divided at all. Each measure is ended by a horizontal line which spans the three vertical lines of the staff, and each beat is ended by a small horizontal line drawn at the center line. Labanotation can relate performer to performer, or performer to object, or body parts to body parts. An example of a circular arm movement, *port de bras* recorded in Labanotation can be seen in Figure 4.

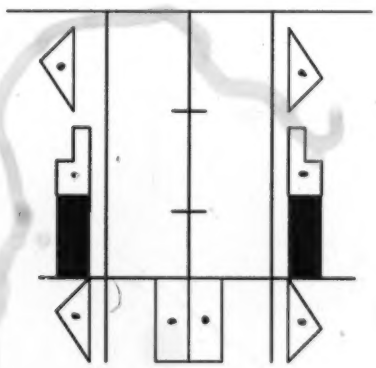


Figure 4

port de bras

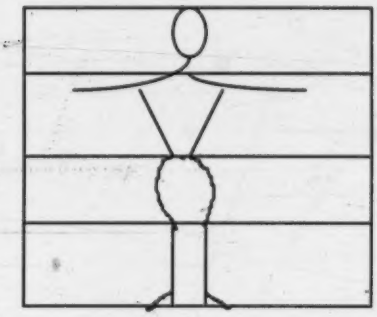
Labanotation can be used to record movements of complexity, in the western world many of the dance forms have adopted Labanotation system to record movements. While Labanotation is capable of notating BN, it is a less than accessible method for teaching BN via interactive, multimedia technology.

Note: As listed in Laban[sic]Notation Scores: An International Bibliograhy, Judy Miner Van Gile has notated BN dancer Balasaraswathi. One of these works is available through the Dance Notation Bureau.

2.2 Benesh notation

Invented by Roudolf Benesh and Joan Benesh in 1956, it records movements using marks on a matrix representing a human figure. Based on a horizontal stave, the movement of the body parts is indicated by projections of their paths in space onto the stave. The various lines of the stave represent the different levels above the floor. In the Benesh system, the concept of matrix representation (horizontal staff) of the body is derived from music notation. They believed the five horizontal lines provide an ideal representation of the human body. The top line represents the top of the head, the next line the shoulder, the third line represents the waist, the fourth line the knee, and the bottom line the floor line (see figure 5). A support line written under the floor line means supporting on the whole foot, on the line shows half toe, and above the line means supporting on point. Further, there are the basic signs to direction signs used for the placement of the extremities, and special signs to indicate the sagittal, forward-backward directions.

BENESH SYSTEM (Matrix representing the performer).



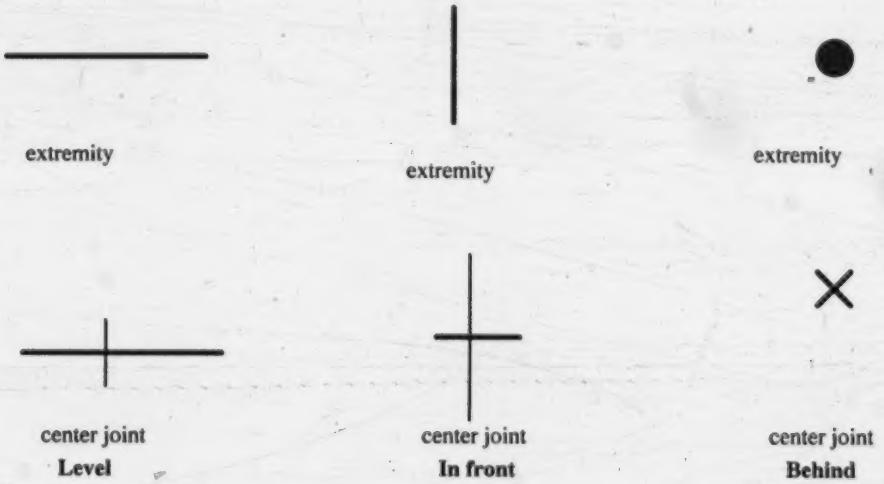


Figure 5

By plotting the placement of the extremities of the arms and legs and the elbows and knees when a limb is bent, various positions are indicated. Movement lines are added to link starting and finishing positions, thus giving a more visual picture of the line of movement. Information that cannot be written by visual means on the five line staff is placed above it. For this purpose additional signs are used consisting mainly of the letters of the alphabet, numbers and a few abstract signs. Signs under the staff indicate stage direction faced, turning, stage location, and direction traveled (see Figure 6).

Additional Signs

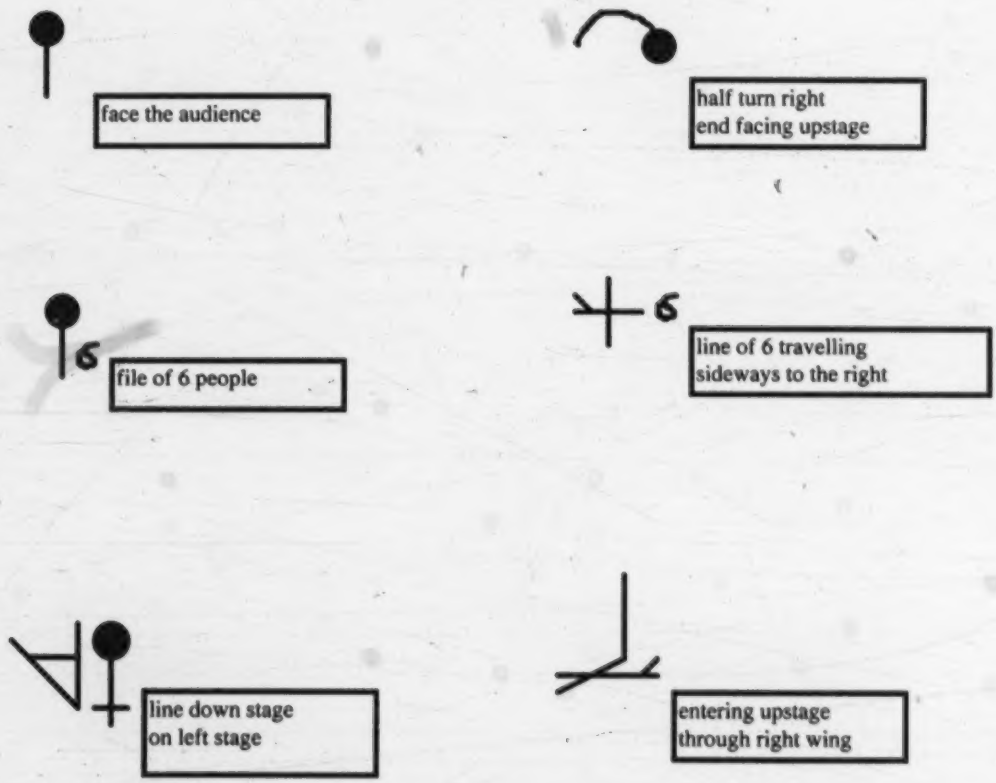


Figure 6

In designing the notation system, the Beneshes approached it as a creation of a unique language for dance. They created some form of basic 'alphabet' to notate dance. As in using alphabets to represent words and thoughts, a set rule of grammar is employed universally. In the same manner they claim the alphabets used in describing dance should also conform to the particular form of dance, he states that, "It is therefore essential for all concerned to know the language of a particular dance style otherwise the eye would not know what to look for and what to discard out of the enormous visual information. The chronologist learns what to leave out rather than what to put in. It therefore follows the notation not only presupposes the art convention but must also disregard certain details. The answer lies in the correct analysis and knowing what to leave out, and the result must arrive again at a simplicity after having gone through so much complexity." (Hutchinson-Guest, 1984, p 103).

Benesh system has been used mainly in recording, learning and teaching ballet. Once again this too has the same draw backs as the Labanotation system, as well it was conceived and designed for the purpose of ballet, thereby missing some elements crucial for BN. Also as Benesh said there is a need for the specific vocabulary knowledge

Chapter 3

System of Descriptions Specific to Bharata Natyam (BN) Analysis

Clearly, perception and understanding of BN are needed in order to describe and analyze the artform. The challenge is to be aware of all dimensions, i.e., spiritual, cultural, emotional as well as physical skills that configure the dance. Ideally the system used for analysis would take all these into account, resulting in a complex system of analysis. However, at the present moment we have yet to devise such a system.

Vatsyayan, a renowned dance scholar, critic, educator and author of many books on Indian dance, makes the point that Indian dance seeks to depict the perfect point or moment of balance along the vertical median so much so that all movements emerge from and return to the point of balance (Vatsyayan 1974, Gaston 1982). The movements in BN are predominantly directly in relation with the pull of gravity; i.e. they do not oppose it, thus sudden leaps and gliding movements are not a dominant part of it. The emphasis in BN is that space is less important than time, and timing of movements conveys a sense of timelessness. According to Vatsyayan (1974, p9), "The Indian dancers preoccupation is not so much with space, as with time, with the dancer constantly trying to achieve a perfect pose to convey timelessness".

Vatsyayan's philosophical description of BN expressing timelessness ties neatly back into the religious inception of BN itself. If Lord Shiva danced the

'cosmic dance' to create the universe, and according to Hindu philosophy Lord Shiva projects timelessness, and infinity, then it is appropriate a dance form created by him would also depict timelessness.

In attempting to extract and analyze the information on BN, as it was written in the treatises *Natyasastra* and *Abhinaya Darpana*, K. Vatsyayan groups parts of the body as follows: "The head forms the first unit and lateral movements of the head are common. The torso is seen as another unit and is hardly ever broken up into the upper or the lower torso. The lower limbs are seen either as straight lines or two sides of an imaginary triangle in space. The upper limbs either follow the lower limbs or weave circular patterns along the space which is covered by the lower limbs. It is the later aspect, along with the use of the torso as a single unit, that gives BN its particularity." (Vatsyayan, 1974, p17). He further claims that "in terms of geometric design the dancer is trying to achieve a series of triangles. The line joining the two shoulders may be conceived as the base of one triangle, and the waist as the imaginary apex of an inverted triangle. From this apex a second triangle is conceived with the thighs as the two sides and the line joining the two knees as the base of this triangle. The third triangle is formed by the space covered by the two calves and the line joining the two knees. The arms reinforce this by forming other triangles on either side; the extended arm forming one side of the triangle and the line joining the hand to the knee suggesting the second side". This states that the human form achieves geometrical forms in time rather than in space, i.e.; the poses that emerge from movements are performed to the rhythmic symbols where time is the essential quality.

Vatsyayan has grouped the head as one unit, the torso as the second unit and the lower limbs as the third unit. In my opinion, this is not a comprehensive identification of all elements that are vital for a BN performance, it is vague and incomplete in its grouping, thus becoming vulnerable for misinterpretation and confusion. BN is an artform dealing with the total body as well as the mind and soul of the performer. In order to dance to perfection the performer needs to tie all three aspects of it together and deliver a skilled rendition of the lyrics/songs she or he is dancing to. In order to express the mind and the soul the performer needs to use facial expressions and hastas. Facial expression and *hastas* also create the mood of the moment. If the eyes, mouth, wrists and fingers are not identified as important elements in the grouping of the units then the initial grouping fails in its comprehensiveness. The arms too need to be identified as an important item as they depict and support the motion, providing depth to the totality of the movement. Next, the omission of feet is inexcusable; feet in BN are the base for balance and movement of any kind, they convey speed and rhythm, and support all poses. Not giving the feet enough prominence in including them as a key element in the groupings is a serious error.

Furthermore, the relationship to triangles obscures the totality of BN dance structure and form. In his analysis, the three triangles neglect to address some of the crucial body features in BN, namely, the arms, wrists, fingers and feet. The imaginary third triangle with the calves as the two sides and the line joining the two knees as the base of this triangle is definitely imaginary, and the majority of the movements and poses would not support it. The entire notion of representing BN in a

triangular formation may be applicable to the static form, but as dance is dynamic it cannot be endorsed as a comprehensive model. It is common to draw stick figures with triangles when illustrating human forms, particularly in animation, and it may be that it is those stick figure illustrations that dictated the triangular notion rather than the BN forms themselves.

Faubion Bowers(1953, p 23) another authority on BN characterized BN by energy, speed, rhythmic force and exuberance bursting within exacting rules and clarity of movements in physical precision. He remarked that any BN pose if arrested in time should reveal the body as a proportional whole, balanced by parallel lines formed by the limbs and connected by angles formed by the limbs' joints. He further claims, the movements of BN present a new concept of the human body, stating that nearly all of the basic gestures of BN are scrupulously avoided in the classic ballet of the west, remarking that it can be completely detached from pictorial description or may interpret songs moods and meanings graphically, stating it is a suggestive art.

In his attempts to classify BN, he followed the general pattern described in *Natya Sastra*, interpreting it to accommodate a broad range of movements. In *Natya Sastra*, BN is divided as *Nritta, Nritya* and *Natya* as identified earlier in the discussion of BN's history. Explaining the term *Natya* as a word that includes song, dance, speech, movement, and scenery in one word, Bowers' notes that it is a combination of everything that makes up a dramatic representation in BN. He claims in his book 'The Dance in India,' (1953, p24), "we in the west have no equivalent for *Natya*; to us theater implies drama, dance implies the absence of stage drama, but *Natya* is inclusive of both. Sanskrit has no single word for dance in our sense. Rather

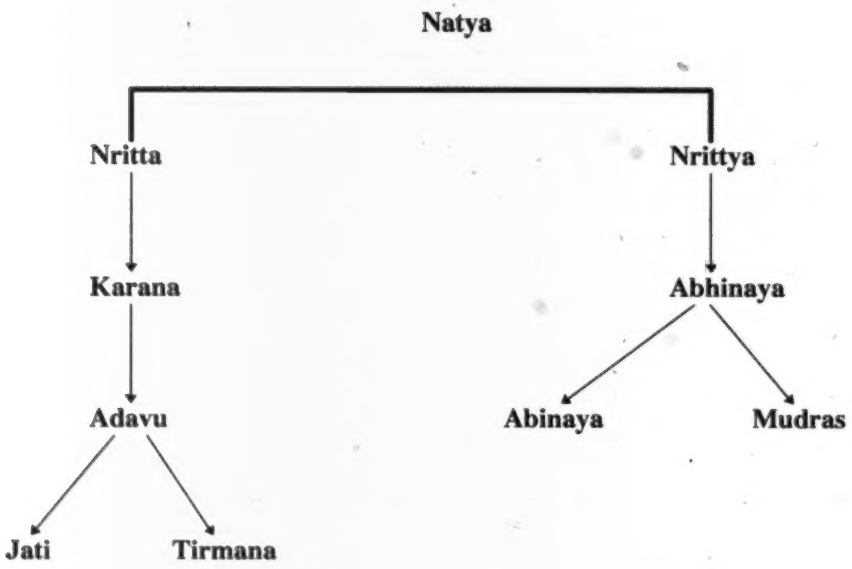
it employs two words equivalent to the two aspects of what we include in the one word dance". The term *Nritta*, is dance pure and simple, i.e.; movements minus the meaningful interpretation of mood or lyrics. Second, *Nritya* refers to expression, interpretation and gesticulation with meaning used to convey mood, feelings and emotions.

Bowers basically identifies the movements and dance items as they are written in *Natya Sastra*, identifying the elements as *nritta, nritya, karana, abhinaya, adavu, mudras, jathi, tirmana* (see Figure 7*)*. He reiterates the existing terms and gives descriptive explanations to them. He does not attempt to group them or classify them in any way, neither does he attempt to group the body in any way. He does, however, discuss the individual body parts such as the hands/palms and feet/legs. He describes the arms as extended at times with hands limply hanging down, or the flat palm shown to the audience suggesting that one is made aware of the special beauty of the palm in movement. He claims that legs are not used as means of moving the body into position, but they in themselves create positions with almost as much variety as their counterparts the arms. He observes that the feet, ankles, toes create symmetry which balances the body from top to bottom, in the same way the hands equalize it from right to left.

In Bowers' description, one not does witness a classification or group, it is merely an identification of existing classification as written in *Natya Sastra*. He does, however, make observations on some body parts and their importance to BN. It is interesting to note how he talks of the hands and feet as important elements of

noteworthiness, compared with Vatsyayan, where Vatsyayan fails to acknowledge their existence.

BN elements and their component subdivision



from the book "The Dance of India" by Faubion Bowers, p25.

Figure 7

Kanak Rele (P.K. Ravindranath 1980, p 34) grouped BN body movements into two groups, volution and revolution. "In the theory of volution, the body of the dancer is divided into two halves at the waist. The lower part, while preoccupied with interpreting the rhythms syllables into movements of the foot, does not generally

follow the course taken by the upper half. The upper half of the body moves in the form of a semi-circle, with the middle of the waist acting as the center, and every movement of the body goes in the form of a volution with its two prongs acting as radii and meeting at the center. The entire arc of the semi circle can be divided into the desired portions, with the radii supporting it and meeting at the center" (P.K. Ravindranath 1980, p 35). This she claims is most obvious in the nritta portions. According to her the other joints of the body, namely the shoulders, elbow, wrist knees and ankle follow approximately the same principle.

Breaking the body into 5 planes (see Figure 8) she attempts to study the formation of body parts and their movements in space, concluding BN takes on a geometric figural representation; mainly triangular representations.

Body Represented in 5 planes

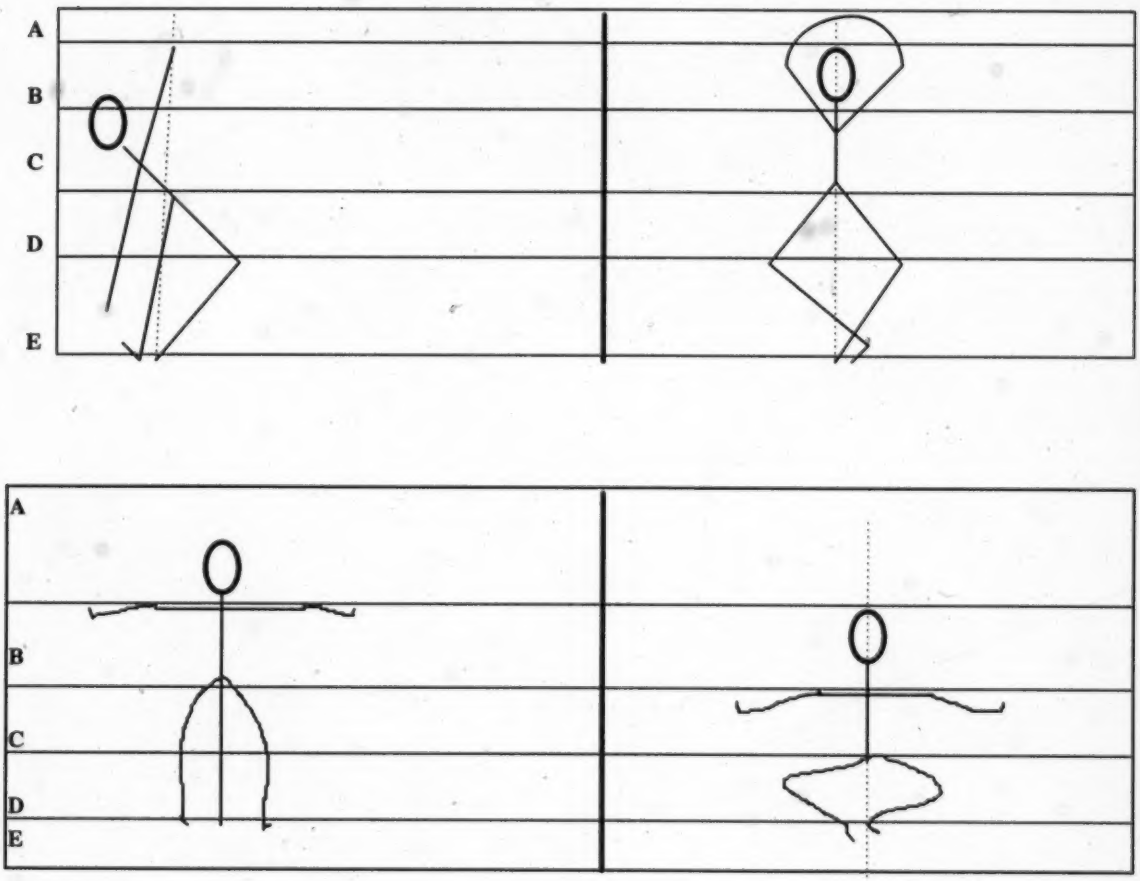


Figure 8

In Rele's attempts at a kinematic analysis for dance, some fundamental elements of kinematics are excluded, namely time. She focuses on space, one element of kinematics, discussing the geometric shape the body assumes in space, and the movement of body that can be described as a "path" taken by limbs in space. She claims different dance styles will involve different geometric patterns as their basis. Her triangle base for BN lacks comprehensive description. Her theories of movements 'volution' and 'revolution' lack support and identification in literature, creating confusion. The semicircle radii analogy of body structure and movements does not lend itself clearly to BN Poses. In BN almost all poses are derived from temple sculptures as discussed in the history of BN. These poses are for most part angular, with very little curvature in structure, as can be witnessed in the temple structures. Curves, if any, are depicted at the waist with a slight deflection from the vertical line. With such minimal importance for curvatures it becomes misleading and trivial to focus on it when there are other vital movements and poses that define and give meaning to BN. Her five plane theory does deal comprehensively with grouping various body sections for further analysis. However, it is unclear what (space) exactly plane A (see Figure 8) is attempting to address. As seen (in Figure 8) plane A imposes an artificial boundary which seems redundant as some movements would extend above and/or below it. The horizontal planes categorized from "A -> E" are undefined and unclear. As well, they appear to change in dimensions, making it impossible to interpret in any meaningful manner.

Chapter 4

Nagendran Description System

Based upon research into the two dominant notation systems used for movement analysis of western dance, the Laban system and the Benesh system, and the existing systems for Bharata Natyam (BN) analysis, the decision was made to create a descriptive system for the purpose of teaching and analysis which could capture both the basic and unique features of BN, and which could be readily interpreted and understood. BN movements do not focus on the muscular formation of human anatomy, but rather, they take the joints and fundamental anatomical bone structure of the human form as their basis. The different parts of the body and movements can effectively be analyzed from this point of view. It is from these key points that most movements originate in both lower and upper limbs. Therefore, the various body parts have been grouped as follows:

Unit 1

head - neck - eyes - mouth

Unit 2

shoulder - arms - torso - waist - wrist - fingers

Unit 3

hip - legs - knees - ankles - feet - toes

The three units of classification are independent of each other, and in performance they execute functions that are unique and separate, but function in harmonious relationship to one another.

Unit 1 head - neck - eyes - mouth

This unit provides the completeness to a BN performance. Unit one executes a complementary set of movements to the other units, as well expresses emotions which are present in the lyrics. When performing *adavus* the eyes follow the wrist and fingers. As well, when moving to lyrics/song the emotions of the song are expressed via eyes. The mouth and head movements lend extra depth for this expression; in essence creating the mood for the performance. The mouth is kept in a semi-smile for the most part. But when performing, the entire facial expression has to express the song/lyrics more dramatically. At performance time a frown, a look of horror, a smile are all clearly expressed. The eyes and mouth are accentuated with make-up, and with jewelry and flowers on the head and hair. Unit one could function independently, or in combination with other units.

The neck joint is the pivot for the movements of the head. The movements executed by the neck are some of the most exotic and unique movements found in BN. These movements can be subtle or exaggerated, they complement the overall dance sequence, giving BN its unique character. The movements are lateral with varied degrees of deflection from the vertical line. The neck movements are reflected in the head movements as lateral, circular, or vertical. Some of these neck

movements can be found in other Indian dance forms as well. They are commonly used to identify Indian Dance as an exotic art form, particularly in the west.

Unit 2 shoulder - arms - torso - waist - wrist - fingers

This unit has a dual purpose; it complements the overall body design as well as functions independently. The torso, identified from the shoulder to the waist, is viewed and used as a single body part. It moves as one body part eliminating separate rib and chest movements. For the most part, the arms move in correlation to the leg(movements) from unit three. For example, if the right leg is extended to the right side then the right arm would also be extended to the right side. The arms are used to convey the speed of an adavu, they also provide the structural formation for poses.

The wrist and fingers together form all the *hastas* for BN, as discussed previously, *hastas* are an essential part of BN, as they convey the meaning of the lyrics, as well as are used as an esthetic element in the adavu. Each *adavu* has its own set of *hastas*. For example, for the *Sarukal adavu* the *hastas* used are *alapdma, kataka-mukha, pataka, shikhara* (see Figure 9).

Hastas for Sarukal adavu

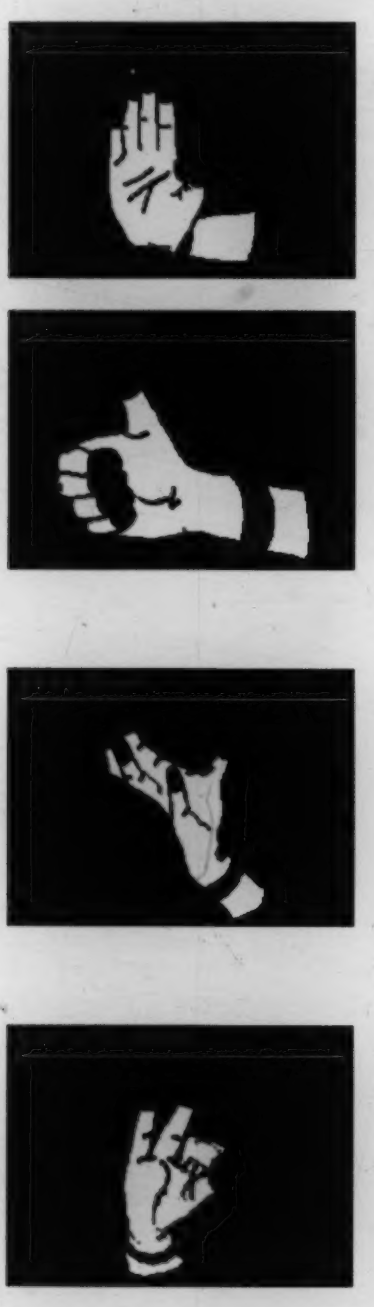


Figure 9

Unit 3 hip - legs - knees - ankles - feet - toes

This unit is the most vital unit for movement in BN. All adavus are generated here. The waist and hips create a base from which movements for the legs and feet are generated. The center of gravity for all movements and poses is here. The speed/tempo for the movement is created by the legs and feet, making it the crucial unit in terms of conveying the essence of time, both tempo and rhythm. The legs provide the structural base for poses. The feet are either planted firmly on the ground, or balanced on toes or heels. They are bare and have an outline painted in color giving a clear view of their movements, they also always have anklets/bells tied at the ankles.

4.1 Dynamic / Kinematic Focus of Analysis

Dynamics is concerned with the study of the motion of an object and the relation of this motion to such physical concepts as force and mass. It is convenient to describe motion using the concepts of space and time, without regard to the causes of the motion. This portion of dynamics is called kinematics. As dance is dynamic, it is appropriate to use kinematic elements to analyze dance.

Space

The concept of movement through space in BN is less important than the concept of time. As most movements are rooted to the ground with feet planted on the ground, leaps and glides through space are not an issue. The dancer strives to achieve a perfect pose to convey timelessness. Bowers and Vatsyayan independently identify this distinction between Western ballet and BN, pointing out that technique used in ballet deals with space as a critical element in its movement

It is then to be expected that if the concept of travel through space is not a primary issue, then the levels in space are also not very crucial for BN analysis. Unlike classical Western dance such as ballet, the conquest of gravity through impressive leaps has no part in Bharata Natyam technique" (G. Jonas, 1992 p60). The primary level for all movements and poses is at ground level. In western systems such as that of Laban, this level is known as the middle level. However, for BN description it is the ground level, as the ground has philosophical implications to culture and religion and therefore, is more significant for BN. Earth is viewed as "Mother" endowed with supernatural powers, as such, "Mother Earth" is worshipped and celebrated in much Indian folklore. In BN the initial step *Thati kumbdu* is a dance movement that requests permission and blessings of the "Mother Earth" before dancing on her. Almost all steps are grounded and keep physical contact with the earth. It should be noted that the occasional leaps and jumps found in BN are an anomaly to the general movement patterns.

The aspect of space that is most crucial to BN is that of shape. Body shape is very essential to BN. Almost all of these body shapes are derived from temple sculptures and have their forms rooted to the ground. The poses express balance and dexterity of the body. Vatsyayan and Rele independently suggest that all poses have a geometric form to them. They are mainly angular and balanced with the center of gravity between the pelvic bones. Legs are generally flexed at the knees and ankles.

Time

Time has been identified by scholars and BN practitioners as the most important aspect of BN. All adavus have 3 variations of speed, called *kalam*, affecting time. The first *kalam* is the base speed, it is slow and is taught first to the students. The second is a faster speed, called the second *kalam*, and the third is the fastest.

The rhythm is expressed in a verbal-symbolic form, called *jethi*. Each adavu has its own set of syllables. As all adavus are executed symmetrically first on the right and then the left side, there exists an entire set of syllables expressing the whole adavu. Following is an example of one adavu.

FIRST THATTADAVU

First kalam

Syllables	*Movement R/L*
Tai ya	Strike right foot to floor once
tai yea	Strike left foot to floor once

Second kalam (*tempo is faster*)

Syllables	*Movement*
Tai ya	Strike right foot to floor once
tai yea	Strike left foot to floor once

Third kalam (very fast tempo)

Syllables	*Movement*
Tai ya	Strike right foot to floor once
tai yea	Strike left foot to floor once

As identified in the Bharata Sastras, (Vatsyayan, 1974), there are three speeds/tempo for each set of rhythmic syllables. The first set is done at a slow pace. The second has an increased pace to it. Third is the fastest speed of execution, it is mostly limited by the body's ability to execute movements at that speed. Most dance items are performed in the first *kalam*(speed/tempo). The third *kalam* is used to express skill and mastery of the adavu. In many cases the music and lyrics used to depict movements/dance will also dictate at what *kalam* these *adavus* should be performed.

Force/Energy

Force is an aspect that exists as uniformly distributed energy throughout the body all throughout performances. When performing particularly to lyrics and songs, the movement connection from one *adavu* to the other is expressed as smooth, constant flow of energy. It is less percussive compared with the force/energy expended during the execution of *adavus*.

4.2 Analysis of Body Units in Relation to Kinematic Elements

Unit One: head - neck - eyes - mouth

For unit one, the key is one of time; as all three *kalams* would apply to unit one. Movement could be in first, second or third *kalam*, depending on the lyrics.

When executing *adavu* in the first and second *kalam*, unit one would follow the wrist movements maintaining the same tempo applied to the rest of the body. When executing the third *kalam* (the fastest), unit one functions independently to the other units, as it remains relatively still and maintains stability of the movement. Unit one has minimal independent invasion of space. Perhaps most important are the lateral movements of the head/neck, which although small are significant insofar as creating a visual image the Westerners identify as Indian dance.

Unit Two *shoulder - arms - torso - waist - wrist - fingers*

In unit two, the torso is not effected by the tempo, however, the arms, wrists and fingers are. They would follow the *kalam* the rest of the units are executing. Arm movements are important for BN, as they, along with the leg movements, are considered pivotal for creating the entire dance movement The space affected would be space surrounding the body. The positional placement and movement of the arms is central to the creation of the unique body designs.

Unit Three *hip - legs - knees - ankles - feet - toes*

Unit three, the most vital unit, comprises the lower body. It is responsible for balance, execution of *adavu*, speed, locomotion. As BN is about expressing rhythmic movements, the focus of expressing rhythmic movements for the three different kalams becomes of utmost importance for this unit. The expression of time is predominantly performed by the third unit, mainly the legs. All movements executed in unit three are symmetrical, executing the right side first, followed by the left, thus

tempo and rhythm would also be expressed symmetrically and equally on each side. Most movements are lateral with feet on the ground. Travel in space is almost non-existent and leaps and jumps are minimal. The space affected would be created by the height of the jump or leap.

Describing BN movements the Nagendran Description System provides a clear consistent and extensive system of description of the *adavus*. The unit groupings creates order and classifications of significance to BN. Utilizing the units each *adavu* can be explained in detail in terms of body positions relating to the *adavu*. Movement transition from one position to the next within the *adavu* can then be analyzed.

BN as a form of dance must be described in a manner that provides the capability for both description of static body position as well as the dynamic body motion. The introduction of the kinematic concepts of time, space and force/energy and their applications to each unit independently allows for in-depth understanding of the movement. Overall the Nagendran Description System provides a system for further analysis and studying of BN.

The Nagendran Description System of BN is presented in the "***Interactive Multimedia Application for Teaching Adavu in BN***".

4.3 Summary

A brief history has indicated the complexity of BN as an artform synthesizing movement, religion, philosophy and culture. For context and possible use, a review of two western notation systems for movement analysis and eastern systems for BN analysis was done. The review has identified some strengths and weakness when one considers their applications to BN. Therefore it was decided that a specialized system of movement description for BN was needed. One such possibility has been described, the Nagendran Description System grouping the body into three units:

Unit 1	head - neck - eyes - mouth
Unit 2	shoulder - arms - torso - waist - wrist - fingers
Unit 3	hip - legs - knees - feet - toes - ankles

The body units were analyzed in relation to kinematic elements, which resulted in identifying space to be important for body shape and design. Force/energy was found to be predominantly evenly distributed through out the whole body. Overall however, time was identified as the most crucial kinematic element in BN. The essence of time permeates through out BN not only in the movements, but also in the philosophical, spiritual, and cultural context.

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Phase III

The Development of Interactive Multimedia Application for Teaching Adavu in Bharata Natyam

(IMATAB)

Chapter 1

Introduction

Many members of the dance community have benefited from the availability of computer technology. Dancers, choreographers, notators, dance teachers and others have experimented with computer technology predominantly as a means of documentation. The synthesis of dance and technology is still in its infancy and on many fronts there is much work yet to be done, particularly in the areas of choreographing and teaching. There have been many efforts to incorporate the art of animation and the performing arts into the emerging medium of computer animation. The proposed creation of a computer teaching tool for dance has its roots in the art of animation.

Unlike other disciplines, dance curricula have made only limited incursions into the technological arena. Dance educators became intrigued and briefly captivated by the potential of computerization (Gray 1983), but progress has been limited by prohibitive costs, the complexity of computers, and the lack of familiarity with computers that most dancers have. However, with the advancement of powerful computers that are affordable and a new generation of dancers with increased computer literacy, once again the feasibility of utilizing the technology has become compelling and the

excitement such mergers create has become of great interest to all segments of the dance community.

According to Gray(1983), computerized animation of dance movement will play an important role in the collection, editing and preservation of the dances of our times. She further claims, seeking an optimum balance between human creativity and computer innovation through computer choreography shows impressive potential. Apart from the professional choreographic need, its usefulness for the instruction of students in dance studios may also be emphasized.

If one follows this trend of thought, then the onus is on the dance community to pursue this new frontier. The dance community views the state-of-the-art technology as a tool for teaching, choreographing, and archiving. There are pockets of dancers and choreographers who are experimenting with the current technology, amongst the notables is Merce Cunningham. Cunningham used the software "Lifeforms" to choreograph the dance sequence "Trackers", and has been a strong supporter of such tools in the dance arena. He claims he uses Lifeforms to visualize movements that he hasn't experienced before. Lifeforms is a choreographic software tool developed by Dr. Tom Calvert et al. at Simon Fraser University (1993). It requires an intense learning phase before one can make productive use of the tool. This is an example of an attempt to make a contribution by the computer science group to meet the need of the artistic world, specifically the dance

world. An extension of this progression is to create teaching tools to enhance the learning that occurs in studios.

Introduction of computer teaching tools in studios could start the process of awareness of computers within the dance students. They can begin to see computers as a resource for learning, and as such computers would be seen as less of an alien item in a dance environment. They become less intimidating, and become part of the learning material comparable to text. The availability in the studio would encourage usage, thus increasing the levels of familiarity, all the while providing valuable information for learning. This early usage of computers for learning can lead to awareness and expectations of using the computer for further complex tasks in dance, such as creating/choreographing dance. Through beginning to use computer tools at the initial stages of learning movement, the equipment gains acceptance and the realization of its usefulness and potential to the dance world becomes very apparent and technology becomes less threatening.

Attempting to bridge the gap between computer technology and dance that would result in enhancing dance teaching, this masters thesis focused on designing a tool for use in the teaching of Bharata Natyam (BN), the **"Interactive Multimedia Application for Teaching *Adavu* in Bharata Natyam (IMATAB)".** Bharata Natyam is an East Indian classical dance form and *adavus* forms the basic steps for this dance. This research will serve as the basis for the development of user friendly interfaces and applications for teaching and archiving dance movements.

Chapter 2

Background

Early attempts of collaboration between dance and computers occurred in the 1960s at the University of Pittsburgh (Gray, 1983). The results of these were not documented, however, they created an immense interest and an awareness of such possible integration. In various parts of the United States many research groups attempted to create systems that could code, create, script dance movements and notations. One such earlier model was Dianne Petty's (J. Gray, 1989, p111), model of a dancer created on a Geometric Design Processor. She initially photographed a series of computer-generated poses and subsequently coordinated these images with music. There was no interactivity once they were digitized.

Important contributions were made by Dr. B. Bernnan at the University of Wisconsin-Madison, who developed a computer assisted methodology for analyzing movements, and by Dr. Judith Gray who developed a system for recording and analyzing dance teacher and learner behaviors (J. Gray, 1989). A most significant progression and awareness in this field was created by Margo Apostolos in 1984 at Stanford University, where she explored the aesthetic implications of robotic movement. The result of the initial question "Can a robot dance?", led to the development of a

technique to program an industrial robotic arm to move in an aesthetic fashion.

Since the initial projects such as those cited above there have been gigantic advancement in computer technology. Many of the initial difficulties experienced by the designers do not exist anymore. For example, the struggles of photographic input into a computer have been eliminated by video cards providing direct video input. Here the computer renders the images into frames that can be manipulated more easily, thus reducing the process time considerably.

The next distinct advancement occurred in the form of systems that were capable of recording dance notation, predominantly for posterity. These computer notation systems were difficult to learn and had limited use; they represented movement at the basic level. One such system is Labanotation (Hutchinson, 1960), where symbolic representations of many movement properties are found in the system. The commands represent instruction to move a limb segment (foot, upperarm etc.) from its current orientation to a new orientation. The functionality of such process is tedious and time-consuming. The usefulness of all such movement notation systems is diminished by their inherent complexity and difficulty of learning. However, Labanotation and the various systems that emerged in that era were the corner stones of current advancement. The possibilities for the use of such applications created a demand for less complex functional computer environments that are user-friendly.

The advancement in technology further created the possibilities of stick figure animation, leading up to the present state of modeling the human body in motion. Calvert (1986) cautions, stating that comprehensive movement analysis and development as ambitious. However, the advancement of computer technology over the past decade has made such warnings less ominous. The creation of new inexpensive, but powerful microprocessors and high-resolution displays are making it feasible for integrated research to move forward with fewer obstacles and relative ease.

2.1 The Science

Three dimensional computer animation can be identified as the science for creating interface for dance. These interfaces enable the display of movement of specific objects. This process can be further divided into object modeling, motion specification and image rendering. As Calvert claims(1982, 1993), all three are strong contributing factors in creating animated movement sequence, however, motion specification has to be singled out as the dominant factor in animating movement. Motion specification translates the ideas of the choreographer into computerized movement, translating them into actual position and orientation for each step within the computer; this process is called motion control (Bruderlin, 1989). The expression of the animation of articulated bodies, such as those of humans, has been recognized as one of the most challenging endeavors. A body is represented by a hierarchical structure of rotational joints where each joint has up to three degrees of freedom

(Calvert 1988, Zeltzer 1983). The human body possesses over 200 degrees of freedom (DOF) and is capable of complex inter-connected movements that ongoing research is still endeavoring to represent. Because human movement is a familiar activity, people are well trained to distinguish realistic from unnatural movements. Computer generated movements of articulated figures therefore will have to meet high standards to achieve acceptance. The large number of DOF problems indicate the non-trivial task of coordinating the limbs of an articulated body to achieve desired motion out of the vast range of possibilities (Zeltzer, 1983).

The desire to create character animation that has a user friendly environment has caused a push for higher level of motion control whereby prior knowledge and standard action are automated and visible to users as parameterized modules (Drewery and Tsotsos 1986, Zeltzer 1983). To achieve realistic execution of movements, dynamics is applied for motion control process by simulating real world objects as they move according to the laws of physics (Amstrong and Green 1985, Calvert, 1982). The drawback is that the movements have to be described in terms of forces and torque, limiting its usefulness for dancers.

2.2 Computer Animation

Computer animation of articulated figures has many applications in a variety of disciplines. In the medical field, accurate human models are used to study human physiology and motion. In biomechanics computer animation

is used to study human movements and gait patterns (Alexander, 1984). The field of robotics has made extensive use of such science (Miura and Shimoyama, 1984). However, McNair et al (1982) claim that in the dance field there exists a need for friendly interfaces that can provide an environment to train dance annotators to record movements using dance notations. Supporting McNair's hypothesis is Dransch et al (1986), stating that computer based interpreters can produce animation by reading and translating visual forms of movement description based on notation language. Herbison-Evans (1982) postulates that choreographers can compose and edit new dance sequences, and Green (1990), states that, in conjunction with video, previous dance master pieces can be viewed, archived and stored for posterity, further stating that dance can provide the computer world with an artistic flavor in dance. As well, these systems can be used to study the interaction of dance partners and illustrate the principles of lead, follow and frame. These systems are, however, dance specific.

Many computer models and editors have emerged emulating the Labanotation methods. In 1974, Zella Wolofsky at Simon Fraser University developed an editor which converted an alphanumeric description of Labanotation into a numerical language describing body position and orientation (Wolofsky, 1974). This was converted into stick figures, successive body descriptions were then separated by time intervals and an interpolation algorithm was constructed to supply the motion between key positions. Calvert and Chapman built a macro processor which translated

various higher level movement descriptions into Labanotation scores (Calvert and Chapman, 1978).

In Waterloo, a computerized Labannotation system named CHOREO-L (Savage and Officer, 1978) was developed by Savage et al. The system accepted scores entered with an acoustic pen acting on a graphical menu overlaid on an acoustic tablet. A database was developed with the input information on the movement description. Each record contained the start and end time for a particular body motion. A time-order sequential interpolation produced animation.

However, these systems are very time consuming to learn and implement, furthermore they do not provide a user friendly environment for choreographers to work in. There is a steep learning curve of the system before the knowledge of the system becomes functional. Even then, the choreographic process is tedious work on the machine. Such an environment did not attract willing participation from choreographers. The developments cited above further emphasize the need for convenient, realistic, user-friendly systems for dance.

2.3 Methods in Animation

The methodology employed by science in animating articulated movements varies. The basic method is *Rotoscoping*, this method digitizes the joint coordinates of all body segments from at least two orthogonal views taken from film or video recording. This is a tedious process and there is a

continues interest in automating this process (Calvert 1986). *Instrumentation* is another method of recording movements, specifically using instruments such as goniometers. The instruments are attached to the subjects and the movements (i.e. joint angles) are recorded in real-time. However, in a dance environment, these methods pose a severe restriction with respect to movement and space. The dancers movements become constrained and therefore inhibited. The SELSPOT and WATSMART instrumentation systems provide for increased freedom of movement with lighter, time-multiplexed light emitting diodes attached to the joints. However, these are very expensive commercial systems that have a steep learning curve, thus making them unattractive to the dance community. This method also requires dancers to be involved during the creation process, whereas the main idea of creating user friendly interfaces is to minimize external involvement including other dancers and to give the choreographer private space and time to create dance sequences with a computer tool. Another drawback is that any change to the original dance sequence, i.e. changing the stage setting, will need a new recording of movements. This defeats the purpose of efficient use of manpower and time. Many commercial animations are produced using the rotoscoping method and or the instrumentation method.

Key-frame animation systems simulate motion by having animators create an ordered set of key frames describing the appearance and position of one or more objects at specific times (Reeves 1981), (Sturman 1984). Interpolation algorithms read the key frames and create a series of in-between

frames containing object positions required to link successive key frames. Motion results when all key frames and in between frames are rapidly played back in sequential order. The drawback here is that in order to animate realistic dance sequences, an inordinate amount of frames have to be generated. This creates a need for mass storage, as well as being time consuming to create these frames. These issues make it less desirable for choreographers to use any interface that employees such technique. However, it is still the most common technique employed in many commercial software applications.

Kinematics systems describe motion by the positions and accelerations occurring at each joint of the articulated figure (Calvert 1982; Wilhelms 1985). This method obtains motion by showing the position of the figure through a series of key frames and in-between frames, or by solving the kinematics equation of motion for each degree of freedom. Unlike keyframing, kinetically calculated positions work well in the 3-D plane. Most articulated figure animation is based on kinematics. This system produces realistic animation sequences and is efficient. However, it is awkward to use with complex figures containing multiple degrees of freedom. It does not account for sudden and unexpected forces acting upon the figures. But that concern is irrelevant to the choreographic problem, as in the dance choreographic environment every movement is accounted for thus eliminating the surprise component of movement.

Dynamic systems produce motion by accounting for forces and torque acting on each body segment (Armstrong et al, 1987). If the mass and the rotational inertia of each body segment is known, the acceleration can be calculated using the law of physics. In the case of articulated figures, the dynamic equations describing motion for each degree of freedom are usually complex second order differential equations which are solved numerically. The system predicts motion based on mechanical principles, however, motion must be specified in terms of forces and torque and this poses a serious drawback for the choreographer in a dance community.

Movement patterns can be specified with *Notation systems,* such systems use an editor and a interpreter to produce animation. Here the movement commands are entered via the editor which is specifically designed for a notation language. The interpreter then processes the desired motion. (Herbison-Evans, 1986). Even though this system lends itself well to create complex scores, it is most suitable to be used by computer animators who are willing to spend long tedious hours in the process of creation. The *Goal directed* models sequentially animate figures to each goal position, they define a sequence of goal directed positions for the figures (Badler et al, 1987). The *Interactive Specification* system involves the interactive specification of body positions in a 3-D graphics environment. In this approach, the user is presented with a space-filling vector representation of the human body on the screen of a graphic workstation. The body can be viewed from any angle with a perspective projection under the control of a mouse or

an equivalent device. The body segment can be picked-up and the orientation of each segment is specified by the user (Van Baerle, 1987).

Knowledge based systems apply artificial intelligence theory to determine movements based on definitions and relationships stored in object and motion knowledge bases (Drewery and Tsotsos, 1986). The initial level is to build a knowledge base of movements characteristic for a body. This will include basic data on the individual being animated and such constraints as the range of movements for specific joints. The knowledge base also includes typical movement patterns for locomotion etc. At the highest level, the system should be able to deduce feasible animation for goal oriented tasks. AI and expert system approaches have been employed by Magnenat-Thalmann(1987) and Drewery and Tsotsos (1986) to study the frame-based approach to goal directed animation.

2.4 Need for Immediate Accessibility of Technology

The methodologies described all serve their specific purposes well. They can be utilized to design applications for dance choreography as well as teaching dance. However, all these models require an enormous amount of time to be spent in creating movements, they are cumbersome and they lack the easy user friendly environment a dance community requires to teach dance and are therefore less than attractive. Applications designed for dance should have immediate usefulness and accessibility for the dance community. For

the purpose of teaching dance, the medium should be capable of emulating dance with minimal distortion.

Animation of dance movements alone would not be sufficient for it to be a comprehensive technique of teaching dance. Text or 2-dimensional images describing dance would also not be adequate in accurate information dissemination. However, a combination of all of these elements would provide the most suitable platform for the purpose of teaching dance. Therefore the medium should be accommodating of audio, video, animation, and text presentation at the user level. The multimedia environment has these characteristics making it the ideal platform for application development for dance. In order to achieve the teaching tool which can be utilized by the dance community the following methodology was developed. Implementing the methodology created the ***Interactive Multimedia Application for Teaching Adavu in Bharata Natyam.***

Chapter 3

Research Purpose

The primary purpose of this research is to devise a computerized method for the teaching and preserving of Bharata Natyam(BN) in its original form. Concerns regarding maintaining the integrity and purity of the movements of BN further prompted this work. In the Western hemisphere, people of many ethnic backgrounds are studying this Eastern classical dance form. On one hand, this interest is positive and encouraging. On the other hand, there is a danger of the form straying from its pure state. Since BN's depth is derived from the Hindu religion, the issues such as dilution leading to loss of integrity and purity of movement, misinterpretation, and misrepresentation become serious factors emphasizing the critical need to archive and preserve the artform. One of the research challenges was to find a medium suitable to teach, preserve and archive such an artform.

In order to achieve this task, one needs to find the ideal medium that is available in the current technological maze. The medium should be technically sophisticated in order to capture and disseminate to the viewer/learner the essence of BN in all its purity of movement. The medium should have the ability to concurrently incorporate video, audio, text and

animation- the key elements of a visually enriched multimedia environment that enhances knowledge acquisition.

Following an extensive literature review and review of hardware/software availability, the author has chosen to apply a modified key frame concept where frames are ordered sequentially and motion is simulated by displaying each frame for a given time measure. This concept is used to create a two-dimensional multimedia interactive tool for teaching BN. Where relevant, information about the movement is stored as frames and later manipulated by design to animate. By virtue of the storing of information, the tool also serves as an archival database. Thus the ***Interactive Multimedia Application for Teaching Adavu in Bharata Natyam (IMATAB)*** fulfills the research purposes.

3.1 Procedure

In attempting to build a user friendly teaching tool for BN dance movements, an initial experiment was designed to study the compositional task of creating a teaching tool for dance using existing commercial software. The usefulness of a multimedia environment in the archiving and dissemination of information in dance was also examined. This experimental tool for teaching Basic Ballet was designed in a multimedia environment. This tool was then tested for its usefulness and acceptance within the dance community. The Basic Ballet Tool was presented to a group of dance practitioners at the Canadian Association of Health, Physical Education Recreation and Dance (CAHPERD) conference in May 1997. Following the presentation, audience members were asked for their responses to the tool. The following questions were asked:

1. If the tool was available do you think you might use it as an aid to teach (ballet) dancing?
2. Would you use similar tools as a teaching aid on another form of dance?
3. Do you think it would be of any use for you or someone you know?
4. What would you change in the tool?
5. What do you like most about the tool?

6. Would the 'test' idea be beneficial to students?

The data collected at the CAHPERD conference and following a presentation to a group of instructors at the University of Alberta was evaluated amongst 20 respondents. There was a 100% positive agreement on questions 1, 2 & 3. Question 4 had suggestions to incorporate audio and extensive text description. Question 5 indicated that animation was the attractive feature. 50% felt the idea of testing students was useful.

Utilizing the information gathered from the test case (Basic Ballet tool), IMATAB was designed to incorporate graphics, audio, video, text and motion animation.

3.2 Outline of the Procedure

The dance vocabulary for BN is extremely specific. The researcher will now define basic BN dance vocabulary that is used in IMATAB and the remainder of the thesis.

"*Adavu*": The term *adavu* means step in BN, and these steps form the basis of movement. BN *adavus* can be classified into 12 categories with each category having sub-categories. Given the finite time frame for the research, only one *adavu* was chosen as an example to demonstrate the technology and computer technique for the purpose of creating the teaching tool. The *adavu* chosen was "*sarukal adavu*".

"Jethi": *Jethi* is a series of verbal sound syllables that indicate rhythmic pattern. They are represented in syllabic form and vary in pattern and tempo. *Jethi* strung together in different time measures are called *"thrimanams"*. For *sarukal adavu*, the *jethi* is *thaka thmi thaka jenu.*

"Hastas": Hand gestures called *hastas* are a pivotal part of BN. They have dual purpose; hand gestures are used to convey meaning and expression, as well as being used as pure decorative stance where no meaning is conveyed. The Hastas are also used to guide the eye movements.

A combination of commercial software packages was used to build the tool. *Authorware* was used as the basic backbone software onto which output from other software packages such as *CorelDRAW* and *AVI frame grabber* was incorporated. *Authorware* is predominantly used for course design with the emphasis on a knowledge base text bank, rather than a movement animation knowledge data bank. This created limitations on design regarding animation of motion. *CorelDRAW* addresses the concern regarding animation, however, is unsuitable to handle the sophistication required to design a teaching tool. Initially basic design features such as possible menu options were drawn-up as blue print for the tool. According to these features and utilizing *Authorware,* the final tool was designed. Video input was used as the initial source of information representing motion capture of the movement. Frames were extrapolated from video input and stored creating a data bank of frames.

Using an *AVI frame grabber* the frames were extrapolated from the video sequence. These frames were then modified in the software *CorelDRAW*- a commercial software package used predominantly for graphics. The modified images were then imported to *Authorware* as graphics interface file (gif) and bit mapped file (bmp). These files were then set as frames in *Authorware*. The animation of motion was programmed using *Authorware* code. This entire process took approximately three months.

3.3 Aesthetic Consideration

As discussed earlier, BN has the cultural, spiritual and philosophical components embodied in dance movements, hence it cannot be learned in isolation. Therefore when designing IMATAB these issues became relevant in the presentation of the *adavu* to the learner. As BN poses were predominantly derived from temple sculptures it was decided appropriate to have images of temple sculptures as backdrops. This combination of visual imagery created with rich textures of deep colors common to the culture, as well as the addition of East Indian classical music in the background enriches the presentation of BN in its contextual sense. This further enhances the learning process.

3.4 Teaching/Learning Consideration

The option of installing a repeat button, text description, and nested links at every stage were key issues that were given considerable thought

during the design process, particularly regarding the teaching and learning of movement in a computer environment. In order to learn a dance movement the student needs to see many repetitions of the movements. The access to see these repetitions must be at the learner's choice and control. The option of absorbing the information and practicing the movement must be at the learner's own pace. Each individual has a unique learning pattern, learning and comprehending varied movements uniquely. The option of the repeat button provides for repetitive viewing and self paced learning of the movement. The images of these buttons were carefully constructed using *hastas* within the *adavu*, inviting reinforcement and subliminal learning to occur. The text description and nested links further enhance and reinforce the learning process.

3.5 Program Structure

A set of preliminary screens introducing the *adavu* designed with temple sculptures as backdrops is presented. Next, a menu of options is presented to teach the *adavu* in the following format: (see Figure 1)

- Real-time performance
- Hastas
- Body positions
- Movement transition
- Slow-motion performance
- Exit

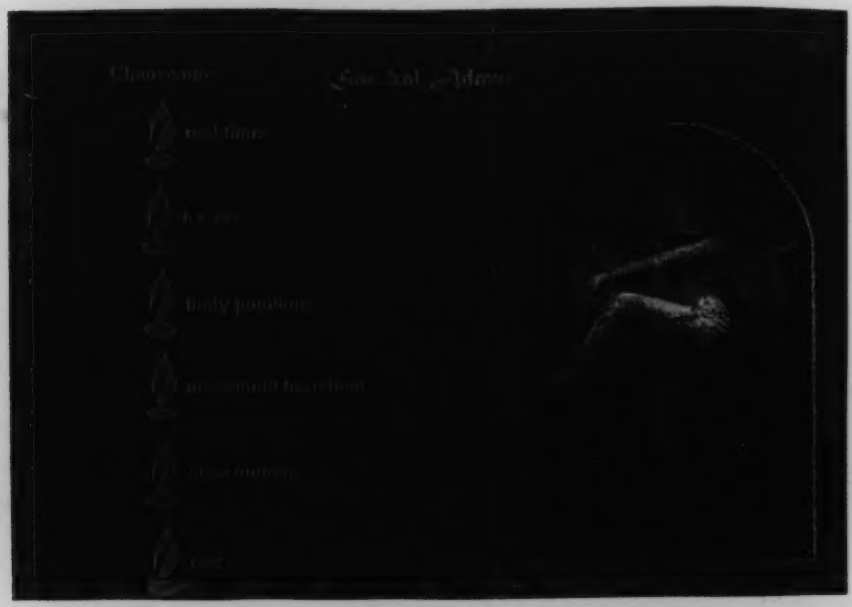

Figure 1

Real-time performance Set on the backdrop of temple sculpture, the real-time performance menu option displays the *adavu* performed in real-time via a video clip (*avi* file) of the movement. *Jethi* syllables *thaka thmi thaka jenu* are concurrently activated as "wav" file providing audio of the *jethi*. A `repeat` button provides the option of multiple viewing of the *adavu*. The `exit` button takes the user back to the main menu. The audio and video combination provides the real-time display on screen (see Figure 2).

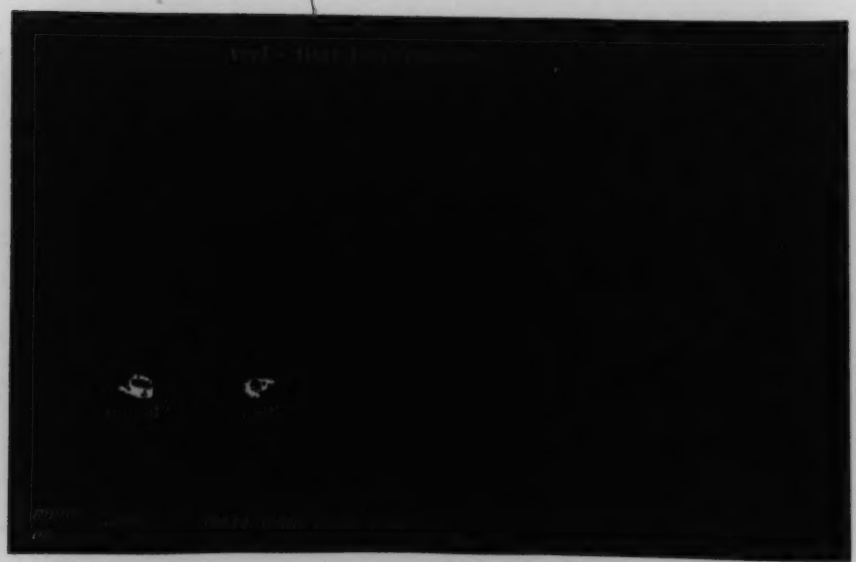

Figure 2

Hastas are hand positions in BN. These are given prominence as they are one of the crucial elements in BN. Each *adavu* has its unique set of *hastas*. For *sarukal adavu*, the *hastas* used are *pataka, alapadma, shikhara, kataka-mukha.* The menu option for *hastas* will proceed to the screen display of all four hastas visible with name tags attached to them (see Figure 3).

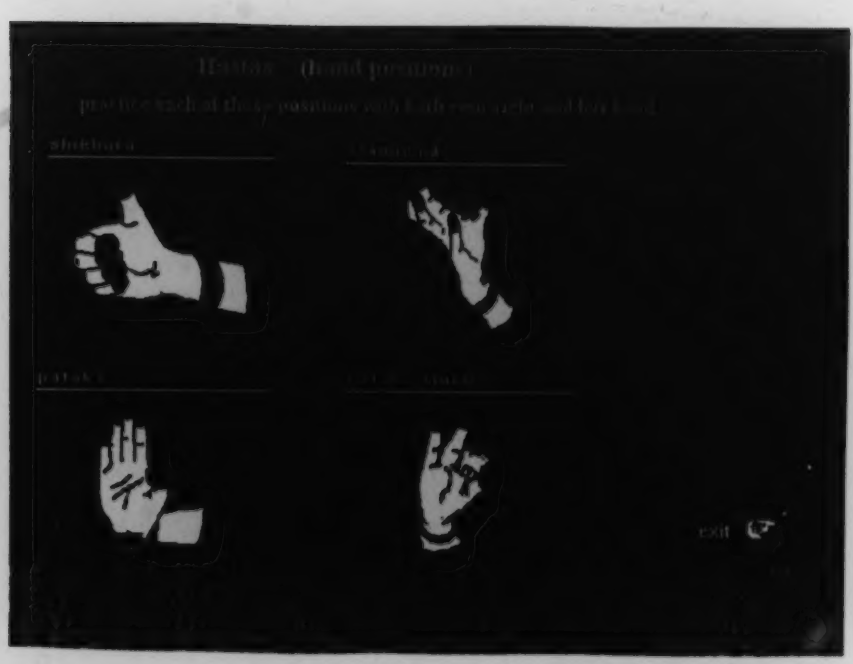

Figure 3

Body positions Set on the backdrop of temple sculpture, the body position menu displays static representations of ten positions taken from the video. The screen provides graphic and text display, with East Indian classical music as background sound. The button options available on the screen permit movements from one position to the next, either in forward or reverse sequence.

The body positions are described in text according to the Nagendran Description System: Unit One = head-neck-eyes-mouth, Unit Two = shoulder-arms-torso-waist-wrist-fingers, Unit Three = hips-legs-knees-ankles-feet-toes. The text display on the screen describes the body position at a particular instant for the movement. Each key body position for the sarukal *adavu* has an extensive text description of the body unit break down according to the Nagendran Description System (see Figure 4).

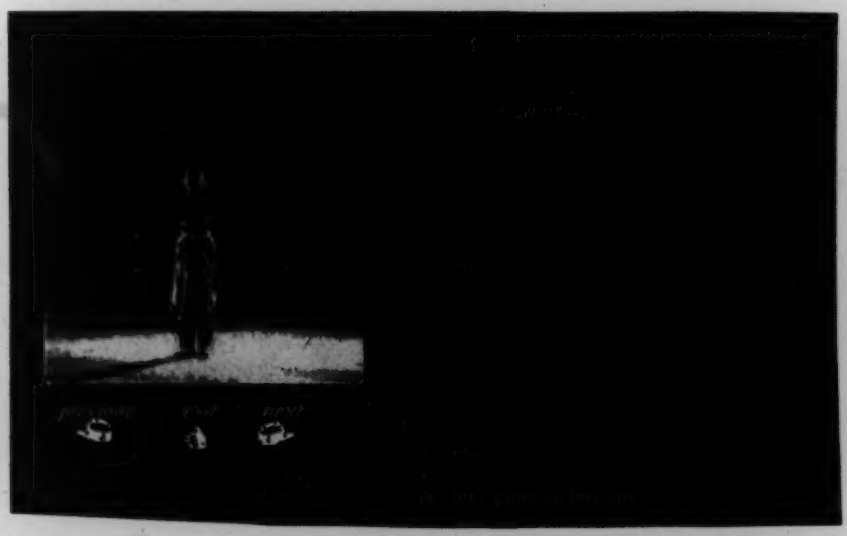

Figure 4

Movement transition Set on the backdrop of temple sculpture, the movement transition menu has a sub-menu option which displays ten key positions and movement transitions between them. A `repeat` button provides the option of multiple viewing of the movement transition. The `more` button provides text description of the movement, as well as the hastas used for that movement. A set of frames are chosen between movements from one position to the next. These frames are then sequentially ordered and displayed in rapid succession. Audio is in the form of *wav file* that provides background East Indian classical music. The screen output is a combination of text, graphics audio and motion (see Figure 5).

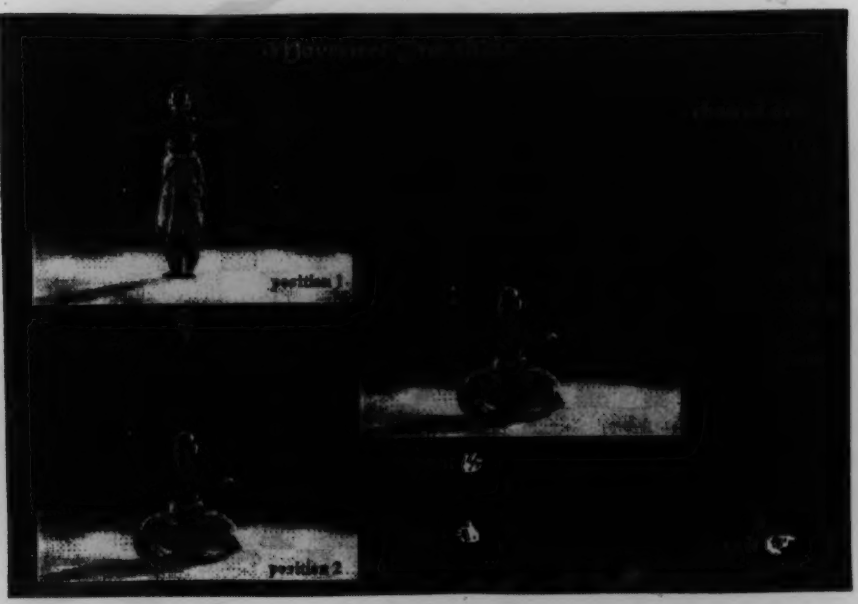

Figure 5

Slow motion performance Set on the backdrop of temple sculpture, the slow-motion performance menu option displays the movement in slow motion. A `repeat` button provides the option of multiple viewing of the movement. The `pause` button freezes the movement. The `main` button takes the user back to the main menu. The screen output is motion only, with East Indian classical music providing background sound (see Figure 6).

Figure 6

Exit Brings the application to a close.

3.6 Usage

IMATAB would be typically used by beginner students when learning the *adavu*. In order to learn a dance movement the student needs to see many repetitions of the movements. IMATAB provides a learning environment where the access to see these repetitions is at the learner's choice and control. The option of absorbing the information and practicing the movement is at the learner's own pace, providing the student with control over the time and space to learn the movement in their unique way.

IMATAB also is a resource material for dance instructors, as it can be reviewed to refresh their knowledge. It can also be used as a demonstration tool at schools where learning occurs in class rooms rather than in a studio.

IMATAB also has achieved the secondary research purpose of archiving BN. As it functions as a database for *adavu,* IMATAB has preserved the *adavus* for posterity.

Chapter 4

Summary

4.1 Summary

Making use of available technology, the research has provided an algorithm to create a tool for the purpose of teaching BN. The Interactive Multimedia Application for Teaching *Adavu* in Bharata Natyam (IMATAB) was designed, it fulfills the dual purpose of being a teaching tool, as well as an archival data base for posterity. IMATAB is designed for the instruction of one *adavu*, *sarukal adavu*. The creation of an application to present the full compliment of *adavu*s for BN would demand many more months of dedicated work. However, this would now be possible due to the successful creation of IMATAB.

The primary purpose of the tool is as a teaching tool. As such it is particularly useful in the initial stages of learning when the language and the movements are foreign to beginners. Students need to be reminded of them more often than what they can be exposed to in the studio. With IMATAB the students have the option of viewing the movements multiple times. The option of viewing the *adavu* in real-time performance, *hastas*, body positions, movement transition, and slow-motion performance provides for a comprehensive study of the *adavu* undertaken at the learners own pace. The

text descriptions that are concurrently visible on screen, along with the audio reinforce the learning process. The Nagendran Description System provides a grouping of body parts by breaking the body into meaningful units that help the student to understand and master the movements.

As mentioned earlier the possibility of loosing the integrity and purity of BN movements in the West was a factor in prompting this research. By creating a teaching tool for BN movements, and when the full compliment of *adavus* are incorporated into the tool, it would serve its secondary purpose of being an archival record.

From this project the researcher has learned that it is very complex and time consuming to realistically mimic dance movements on a computer if the images are drawn from other than video clips. There is a compromise on image and movement quality when trying to animate articulated figures. The test case design of the "Basic Ballet Tool" brought to attention the problems of animating movements that are exactly that of a dancer. For the "Basic Ballet Tool" scanned images were used as initial input and this presented a less realistic display of movements. Therefore, in the design of IMATAB video input was used as initial motion capture, and frames were derived from this initial input. Even so, there is still some degree of compromise in the movement quality displayed. This again reinforces the need for better technology for motion capture and movement animation. This problem was addressed through the addition of text descriptions of the movements on screen to help clarify the movements. Furthermore, an assumption was made

that teachers and students are somewhat knowledgeable in use of computers. Given the proliferation of technology in all aspects of life this assumption seemed moderate.

The information collected from the practitioners at CAHPERD supported the need for and interest in such teaching tools in the dance studios. Although responses were received from only a small number of dance practitioners, it does indicate support for further development of computer teaching tools for dancers. When limited resource materials are available to dance students, these types of teaching tools and aids become very valuable. The student population is becoming more skilled in using computers and therefore it makes sense to have teaching resources available in this medium. In an electronic age, the medium of knowledge dispersion will continue to be via computers.

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Conclusion

Phase One of this Masters thesis identified the need for a specific descriptive system for Bharata Natyam (BN) for the purpose of teaching *adavus*. This issue was addressed by designing the Nagendran Description System grouping the body into three units: Unit 1 = head - neck - eyes - mouth, Unit 2 = shoulder - arms - torso - waist - wrist - fingers, Unit 3 = hip - legs - knees - feet - toes - ankles. The body units were analyzed in relation to kinematic elements space, time, and energy/force, identifying time as the most crucial kinematic element in BN.

Phase Two of the thesis was the creation and implementation of IMATAB. IMATAB can be accessed via the University of Alberta Library. It is a computer disk to be used in an *Intel, Windows 95* platform.

Phase Three of the thesis was a discussion of computer technology/methodology providing background information and content of technology and dance mergers, it identified research that deals with computer notation systems, dance choreography systems and movement animation systems. This phase also describes the procedural steps for building IMATAB.

IMATAB represents an attempt to pioneer the process of motion and animation of dance, making computer technology useful, desirable and available to the dance community. The preliminary exposure the tool has received amongst members of the dance community and the engineering community has been positive. Each group felt that they could acquire knowledge of the *adavu* and were able to learn and execute the movement. Not only has IMATAB succeeded in its ability to function as a teaching tool, but also it provides the algorithm for the future creation of such tools for any form of dance and structured movements.

IMATAB would be typically used by beginner students when learning the *adavu.* IMATAB provides a learning environment where the access to see repetitions of the movement is at the learner's choice and control. The option of absorbing the information and practicing the movement is at the learner's own pace, providing the student the opportunity to learn the movement in their unique way. IMATAB also is a resource material for dance instructors, as it can be reviewed to refresh their knowledge. It can also be used as a demonstration tool at schools where learning occurs in class rooms rather than in dance studios.

Apart from serving a teaching function, the application can be used as an archival tool for BN *adavus*. The archiving of movements of articulated figures in a multimedia environment has many applications in a variety of disciplines. Multimedia applications and interfaces have the potential to become one of the most powerful forms for communicating ideas, searching

for information, and manipulating/exploring new concepts of communication media ever developed. Such multimedia platforms provide a strong communication environment referring to the representation, storage, retrieval and dissemination of machine-processed information expressed in multiple media, such as text, voice, graphics, images, audio and video.

The creation of IMATAB paves the way for future research in designing knowledge based systems and data bases which can be used for complex tasks in dance such as choreographing, multiple figure animation, spatial stage design for dance. IMATAB can be used as a building block to add historic content of BN, ethnographic information, etc. making it useful for dance historians and the study of BN dance.

IMATAB is the product of inter-disciplinary research that is emerging within the research communities. The current stream of technological advancements have originated from such mergers. Such integration provides a holistic approach to arts and science giving it uniqueness and depth. Hopefully IMATAB will pave the way to more exciting advancements in research within the academic and artistic community.